Green Energy from the Blue Ocean

James A. Yoder
Dean
Woods Hole Oceanographic Institution

Charles H. Greene
Director
Ocean Resources and Ecosystems Program, Cornell University

Christopher M. Reddy
Director
Coastal Ocean Institute, Woods Hole Oceanographic Institution

"Energy is the lifeblood of modern society." But it doesn't all have to be based on fossil fuels. To mitigate global warming, our future world will have to rely on a mix of strategies—including nuclear power and new non-carbon sources such as wind, solar, wave, tidal, and geothermal. Geo-engineering will also be required if we are to achieve the goal of reducing carbon dioxide (CO_2) concentrations to 350 parts per million (ppm) from today's level of 387 ppm. The ocean, as well as ocean scientists and ocean engineers, have a role in all of these future energy strategies.

Northeastern states are keenly interested in offshore wind farms because the strong and low-turbulent winds over the coastal ocean from Cape Hatteras north into the Gulf of Maine are ideal for this renewable energy source. Installing large offshore wind farms will provide investment opportunities in construction companies as well those involved in land-based and offshore support. Governor Carcieri of Rhode Island (RI), whose motto for new sources of energy for his state is "spin, baby, spin," is pushing hard to have RI become the first state to have power provided by an offshore wind farm. Deepwater Wind initially plans eight turbines near the coast of Block Island, RI with more ambitious plans to follow. Governor Carcieri believes that if RI

Yoder, James A., Charles H. Greene, and Christopher M. Reddy. "Green Energy from the Blue Ocean." *Journal of Environmental Investing* 1, no. 1 (2010).

can show investors that offshore wind power works, then RI could become the center for manufacturers of wind farm components serving the entire East Coast.

Chinese companies have quickly become the leading domestic producer of wind turbine blades to support the very aggressive Chinese wind power initiative. But there are other components for offshore wind farms besides just the blades that will provide additional investment opportunities. American Superconductor Corporation (AMSC), whose subsidiary Windtec builds complete electrical systems (control, converter, and pitch) for wind turbines, announced in January 2010 that it will design and co-develop five-megawatt (MW) offshore wind turbines with one of China's largest wind turbine manufacturers, Donfang Turbine Company, Ltd. Thus, US companies are involved in the US and abroad in the offshore wind power industry providing domestic investment opportunities for those who see potential in this source of renewable energy.

Nuclear power is gaining new attention and was specifically mentioned in the US President's recent State of the Union speech. Russia is considering small nuclear power plants deployed on 150-meter-long non-self-propelled floating vessels with the first to be completed by 2012. Each vessel can provide up to 70 MW of electricity and up to 300 MW of heat—enough to serve cities of 200,000 people. One advantage of small plants is that they can be deployed closer to the users than large, land-based plants, thus reducing transmission losses. Small, floating nuclear plants may seem like a far-fetched idea, but more than 150 nuclear-powered vessels have been built and many are operating today. Thus, there are well-tested designs, as well as a database available for risk analysis. The same technology could also be developed for energy-intensive desalination. More than half of the world's population lives within 200 kilometers of the coast and will be increasing its demands for power and fresh water. Successful and safe designs for small, floating nuclear power and desalinization plants potentially have a large international market.

Geo-engineering approaches that extract carbon dioxide from the atmosphere or otherwise mitigate the warming effect of greenhouse gases are another strategy to help stabilize CO_2 at 350 ppm by the end of the twenty-first century. Geo-engineering was the elephant in the room at the recent Copenhagen Summit. We are particularly enthusiastic about growing marine algae in facilities on land. Marine algae produce at least ten times more lipids (or oils) per acre than soy and other terrestrial crops, may not require freshwater, use plant nutrients very efficiently, and can be grown on non-arable land. Calculations show that growing algae on 7% of the non-arable land projected to be available in 2050 could produce enough biofuels to replace all of the oil needed in the transportation sector. These estimates have been extrapolated from small-scale demonstration projects (acres or less). Transitioning to large-scale production of algal-based biofuels will face numerous hurdles. Ocean scientists with their vast experience in coastal ecosystems and phytoplankton ecology are well-suited to overcome these challenges.

Algae cultivation can have a significant environmental impact, such as a demand for fertilizer. Using wastewater as a source of plant nutrients could offset much of the environmental burdens associated with algae cultivation. Assuming that algae can be grown and then burned with little

or no net increase in greenhouse gases or other significant environmental impacts provides a strong argument that algal-based fuels should be excluded from carbon caps or carbon taxes.

As for all technologies, the impact of constructing the type of facilities mentioned above will require assessing and monitoring environmental impacts. New sensors and ways to remotely handle and interpret large amounts of real-time sensor data will be required. Companies involved with developing, installing, and operating sensor networks in the ocean and in land-based algal farms to support new energy technologies also offer investment opportunities.

Our energy portfolio must be diversified to reduce society's carbon footprint on the Earth. The ocean can provide a diverse array of opportunities. Investments in ocean-based energy sources are needed, and ocean scientists and engineers will be essential for progress in this endeavor of such importance to society.

Biographies

Jim Yoder is currently the Vice President for Academic Programs and Dean at the Woods Hole Oceanographic Institution (WHOI). Before moving to WHOI in 2005, Dr. Yoder was a Professor at the Graduate School of Oceanography (GSO), University of Rhode Island, where he conducted research, taught graduate courses and advised MS and Ph.D. students. He served 5 years as GSO Associate Dean in charge of the graduate program in oceanography and 1.5 years as Interim Dean of the School. Dr. Yoder has also held temporary positions in the Federal Government including as a Program Manager at NASA Headquarters (1986-1988 and 1996-1997) and as Director of NSF's Division of Ocean Sciences (2001-2004).

Dr. Charles Greene is Director of the Ocean Resources and Ecosystems Program and a Professor in the Department of Earth and Atmospheric Sciences at Cornell University. He received his PhD in Oceanography from the University of Washington in 1985 and was a postdoctoral fellow at the Woods Hole Oceanographic Institution (WHOI) in 1985-86. Dr. Greene maintains a visiting scientist position at WHOI and coordinates the new Cornell-WHOI Masters of Ocean Science and Technology (MOST) Program. Presently, his primary research focuses on assessing the impacts of climate forcing on marine ecosystems. He is also working with colleagues at Cornell's Energy Institute on new approaches to algal bio-energy with carbon capture and storage.

Christopher Reddy is the Director of the Coastal Ocean Institute at Woods Hole Oceanographic Institution. He studies the production and environmental impacts of bio- and fossil fuels. Chris has advised members of the US House of Representatives and Senate, Department of Homeland Security, Department of Defense, and the President's Council on Environmental Quality on renewable energy sources. He received his BS in chemistry from Rhode Island College and PhD in chemical oceanography from the University of Rhode Island.

Yoder, James A., Charles H. Greene, and Christopher M. Reddy. "Green Energy from the Blue Ocean." *Journal of Environmental Investing* 1, no. 1 (2010).